

CLAIMS

1. A pumping device for supplying a diluted sample to an analyser, comprising:

5 a mixer arranged to mix a sample with a diluent to form the diluted sample, said mixer being disposed between a first and a second conduit such that, in use, a sample enters the mixer through the first conduit at a first flow rate and a diluent enters the mixer through the second
10 conduit at a second flow rate, the mixer being arranged so that said diluted sample exits the mixer through a third conduit at a third flow rate, said third flow rate being substantially equal to the sum of the first and second flow rates;

15 pump means for pumping fluid through the mixer and into the analyser; and

a pump controller arranged to receive data from the analyser indicative of the amount by which the sample is diluted and to control the pump means so that any of the
20 first, second or third flow rates are adjustable with respect to one another in dependence upon the received data.

2. A device according to claim 1, wherein the pump means comprises at least two pumps, one pump being disposed on one
25 of the first, second or third conduits.

3. A device according to claim 1 or 2, wherein the controller is arranged to receive data in real time from the analyser for real time adjustment of the pump means.

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4. A device according to claim 1, 2 or 3 wherein a dilution factor by which the sample is diluted is calculable

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from the ratio of the first and second flow rates, and the controller is arranged to adjust the dilution factor by controlling one or more of the pump means.

5 5. A device according to claim 1, wherein either the sample or the diluent contain an internal standard which comprises a predetermined amount of a known substance, and a dilution factor by which the sample is diluted is calculable by comparing the detected amount of said internal
10 standard by the analyser with the amount of internal standard in the sample or diluent.

6. A device according to claim 2, wherein a first pump is disposed on the third conduit and a second pump is disposed
15 on either the first or second conduit, wherein the first pump is arranged for substantially constant flow of the diluted sample to the analyser.

7. a device according to claim 4 and 6 or claim 5 and 6,
20 wherein the controller is arranged to adjust the dilution factor by controlling the flow rate of the second pump.

8. a device according to any preceding claim, wherein the pump means comprise one or more piston pumps.

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9. A device according to claim 1, wherein the analyser is a mass spectrometer.

10. a device according to claim 9, wherein the analyser is
30 an inductively coupled plasma mass spectrometer.

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11. An analyser for analysing a sample, comprising a pumping device according to any preceding claim.

12. An analyser according to claim 11, wherein the analyser
5 is a mass spectrometer or an inductively coupled plasma mass spectrometer.

13. A method for diluting a sample prior to analysis in an analyser, using a pump system comprising
10 a first pump means,
a diluent for diluting the sample,
a mixer for mixing the sample and diluent,
a first conduit disposed between a sample container and the mixer,
15 a second conduit disposed between a diluent container and the mixer, and
a third conduit disposed between the mixer and the analyser,
wherein the pump means draws sample through the mixer,
20 so that the flow rate of diluted sample along the third conduit is substantially the sum of the flow rate of diluent along the second conduit and the flow rate of sample along the first conduit, and a controller controls the pumps means to adjust the first, second or third flow rates with respect
25 to one another.

14. A method according to claim 13, wherein the flow rates can be adjusted in real time.

30 15. A method according to claim 13 or 14, wherein the third rate is substantially constant and a dilution factor is adjustable by varying the first and/or second flow rates.

16. A method according to claim 13, further comprising,
when another sample requires dilution, the additional
steps of;

5 i) replacing the sample container with the another sample
container containing a second sample;

ii) varying the first rate to substantially the third flow
rate for a predetermined time; and

10 iii) after the predetermined time, reducing to the first
rate so that the sample is diluted by a dilution factor;
wherein the predetermined time is substantially the
time taken for the second sample to be transferred from the
another container to the mixer at the first rate.

15 17. A method for diluting a sample, using a pump system
comprising,

a first pump means,

a second pump means,

a diluent for diluting the sample,

20 a mixer for mixing the sample and diluent,

a first conduit disposed between a sample container and
the mixer,

a second conduit disposed between a diluent container
and the mixer, and

25 a third conduit disposed between the mixer and the
analyser,

the first pump means being arranged to pump the sample
or the diluent at a first or second flow rate along the
first or second conduit respectively, to the mixer,

30 the second pump means being arranged to pump the
diluent or diluted sample at a second or third flow rate

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along the second or third flow rate along the second or third conduit to the mixer or analyser respectively:

the method comprising;

- a) pumping the diluted sample between the mixer and the
5 analyser at the third rate;
- b) pumping the sample at an initial rate for a predetermined time;
- c) after the predetermined time, reducing the initial rate to the first rate; and
- 10 d) mixing the sample with a diluent to dilute the sample; wherein, the initial rate is substantially the third rate,

the predetermined time is the time taken for the sample to be transferred from the container to the mixer at the
15 initial rate; and

the third, second or first flow rate respectively is substantially equal to the difference between the second and first, third and first, or third and second flow rates respectively.

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18. A method of supplying a diluted sample to an analyser for analysis, comprising;

diluting a sample by mixing said sample with a diluent in a mixer,

25 pumping said diluted sample to the analyser from the mixer, and

controlling the dilution factor by which the sample is diluted by controlling the flow rate of the sample and/or diluent to the mixer,

30 wherein the controlling of the dilution factor step is carried out in response to data received by a pump controller from the analyser.

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19. A method according to claim 18, wherein the data is received in substantially real time from the analyser.

5 20. A method according to any of claims 13 to 19, further comprising;

disposing an internal standard into the sample, said internal standard comprising a known concentration of a predetermined substance, and

10 determining the factor by which the sample is diluted by comparing the detected concentration of the internal standard with the known concentration of the internal standard in the undiluted sample.

15 21. A method according to claim 20, wherein a second internal standard comprising a known concentration of a second predetermined substance is disposed in the sample and the diluent at the same second concentration levels.

20 22. A method according to claim 20 or 21, further comprising;

determining the dilution factor from the amount of the first internal standard detected by the analyser,

determining a correction factor by comparing the
25 determined dilution factor with an expected dilution factor, and

using the correction factor to correct analyser data.

23. A computer program which, when run on a computer,
30 carries out the method according to any of claims 13 to 22

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24. An electronic carrier means on which is stored the computer program according to claim 23.

25. A dilution device for diluting a sample for analysis by
5 an analyser, comprising

a first pump means,

a second pump means,

a diluent for diluting the sample,

a mixer for mixing the sample and diluent,

10 a first conduit disposed between a sample container and the mixer,

a second conduit disposed between a diluent container and the mixer, and

a third conduit disposed between the mixer and the
15 analyser,

wherein one of the pump means is arranged to draw sample along the first conduit for passage through the mixer,

the other of the pump means is arranged to draw diluent
20 along the second conduit for passage through the mixer, the pumps being arranged so that the flow rate of diluted sample along the third conduit is substantially the sum of the flow rate of diluent along the second conduit and the flow rate of sample along the first conduit.

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26. A pumping device for pumping a diluted sample to an analyser for analysis, comprising

first pump means for pumping the sample through a first conduit at a first or second flow rate to a mixer,

30 a second pump means for pumping the diluted sample at a second flow rate through the third conduit to the analyser,

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the mixer being arranged for mixing the sample with a diluent for dilution of the sample,

wherein the first conduit is disposed between a sample container and the mixer, the second conduit is disposed
5 between a diluent container and the mixer, and the third conduit is disposed between the mixer and the analyser; and

wherein the third, flow rate is substantially equal to the sum of the second and first flow rates.

10 27. A device according to claim 25 or 26, further comprising a pump controller for monitoring and/or adjusting the first or second pumps during operation.

28. A system according to claim 27, wherein the controller
15 is a PC, and

the controller is arranged to receive data from the analyser for real time adjustment of the pumps.

29. A system according to claim 25 or 26, wherein the mixer
20 comprises two or more input tubes, a mixing portion and an exit tube,

a first input tube being arranged for communicating the sample to the mixing portion,

a second input tube being arranged for communicating
25 the diluent to the mixing portion.

30. A system according to any of claims 25 to 29, wherein the third rate is substantially equal to, or greater than, the first rate, and a dilution factor is determinable by the
30 ratio of the first and second rates.

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31. A system according to claim 25 or 26, wherein the second pump means is arranged for substantially constant flow and the dilution factor can be adjusted by varying the first rate.

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32. A system according to claim 26, wherein the first pump means is disposed on the second conduit, or the second pump means is disposed on the second conduit.

10 33. A method for diluting a sample prior to analysis in an analyser, using a pump system comprising
a first pump means,
a second pump means,
a diluent for diluting the sample,
15 a mixer for mixing the sample and diluent,
a first conduit disposed between a sample container and the mixer,
a second conduit disposed between a diluent container and the mixer, and
20 a third conduit disposed between the mixer and the analyser,
wherein one of the pump means draws sample along the first conduit for passage through the mixer,
the other of the pump means draws diluent along the
25 second conduit for passage through the mixer,
so that the flow rate of diluted sample along the third conduit is substantially the sum of the flow rate of diluent along the second conduit and the flow rate of sample along the first conduit.

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34. A method according to claim 33, wherein the system further comprises a controller for monitoring and/or

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adjusting the first or second pumps, or their respective flow rates, and

wherein the flow rates can be adjusted in real time.

5 35. A method according to claims 33 or 34, wherein the third rate is substantially constant and the dilution factor is adjustable by varying the first or third rate.

36. A method according to claim 33, further comprising,
10 when another sample requires dilution, the additional steps of;

i) replacing the sample container with the another sample container containing a second sample;
ii) varying the first rate to substantially the third rate
15 for a predetermined time; and
iii) after the predetermined time, reducing to first rate so that the sample is diluted by a dilution factor;

wherein the predetermined time is substantially the time taken for the second sample to be transferred from the
20 another container to the mixer at the first rate.

37. A method for diluting a sample, using a pump system comprising,

a first pump means,
25 a second pump means,
a diluent for diluting the sample,
a mixer for mixing the sample and diluent,
a first conduit disposed between a sample container and the mixer,
30 a second conduit disposed between a diluent container and the mixer, and

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a third conduit disposed between the mixer and the analyser,

the first pump means being arranged to pump the sample or the diluent at a first or second flow rate along the

5 first or second conduit respectively, to the mixer,

the second pump means being arranged to pump the diluent or diluted sample at a second or third flow rate along the second or third conduit to the mixer or analyser respectively:

10 the method comprising;

a) pumping the diluted sample between the mixer and the analyser at the third rate;

b) pumping the sample at an initial rate for a predetermined time;

15 c) after the predetermined time, reducing the initial rate to the first rate; and

d) mixing the sample with a diluent to dilute the sample; wherein, the initial rate is substantially the third rate,

20 the predetermined time is the time taken for the sample to be transferred from the container to the mixer at the initial rate, and

the third, second or first flow rate respectively is substantially equal to the difference between the second and first, third and first, or third and second flow rates
25 respectively.

38. A computer program which, when run on a computer, carries out the method according to any of claims 33 to 37.

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39. An electronic carrier means on which is stored the computer program according to claim 38.